

Development of Multicomponent (ZrHfTaTi)C via Sequential Addition of Oxides to ZrO₂ using Carbothermal Reduction

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The present study reports the investigation on the combined synthesis and densification of rock-salt type (ZrHfTaTi)C via carbothermal reduction and Spark Plasma Sintering. By systematic addition of metallic elements from ZrC to HfTaTiZrC, the effect of increasing chemical complexity on shrinkage behavior, microstructure, densification, and basic mechanical properties was investigated in ZrC, HfZrC, HfTiZrC, and HfTaTiZrC. While the densification onset temperature decreased with added components, shrinkage behavior became parabolic, indicating diffusion-limited kinetics. Notably, the densification rate significantly decreased from $\sim 0.063 \text{ min}^{-1}$ to 0.025 min^{-1} in the multicomponent system, quantitatively confirming the “sluggish diffusion” effect driven by compositional complexity. Microstructural analysis confirmed the formation of a homogeneous grain structure of carbide solid solution phases. Consequently, nanohardness rose significantly from $\sim 27.5 \text{ GPa}$ (ZrC) to $\sim 34.2 \text{ GPa}$ (ZrHfTaTiC) due to solid solution and lattice distortion effects. These findings establish a direct link between compositional complexity, retarded sintering kinetics, and enhanced mechanical property, providing a framework for designing high-entropy ultra-high temperature carbides and understanding the effect of systematic addition of element on multicomponent carbides

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Yes

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